Clinician Satisfaction With Computer Decision Support in the Intensive Care Unit

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The purpose of this study was to determine baseline user satisfaction for 2 computer decision support systems (DSSs) with demonstrated improvement in patient outcome used in a burn intensive care unit. We conducted a survey of staff members of a 16 bed burn intensive care unit (n = 82) using a written, anonymous questionnaire to determine satisfaction for 2 DSSs: a commercial glycemic management system and software program to guide initial burn fluid resuscitation. Staff members are not yet convinced of a positive correlation between DSS technology and patient outcomes. We suggest user satisfaction may be generally improved for DSS with concentration in the areas of interface, information, and communication.
Keywords: Clinician satisfaction, Computer decision support systems, Intensive care unit

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The introduction of computer decision support systems (DSSs) in the clinical arena offers the opportunity for standardized care and potential for improved patient outcomes.[1-4] Computer DSSs have been shown to improve individual clinicians' performance by up to 64%.[4] The goal of DSS is to provide clinicians with real-time data and recommendations that guide their decision making process; however, clinician acceptance is a vital component of DSS success.

We recently adopted 2 computer DSSs in our burn unit, one to guide insulin infusion for glycemic control (EndoTool; Hospira, Inc, Lake Forest, Illinois) and the other to direct initial fluid administration for burn injury (Burn Resuscitation DSS; US Army Institute of Surgical Research, San Antonio, Texas). The EndoTool uses the patient's previous 5 serum glucose levels and amount of insulin required to attain those levels to predict the amount of insulin required to achieve a target glucose range defined by the medical director (Figure 1). In a similar fashion, the Burn Resuscitation DSS uses the patient's previous 3 hourly urinary outputs to determine the amount of crystalloid infusion required to achieve a target urinary output in the subsequent hour (Figure 2). These systems are available at the computer terminal located at each patient's bedside electronic medical record; they operate from a mainframe server located elsewhere in the hospital. Both DSS programs are considered open-loop systems in that the user can accept or decline the generated recommendation. Such control is essential as the clinician understands the complete clinical picture for a patient, yet limited information is entered into these DSSs.

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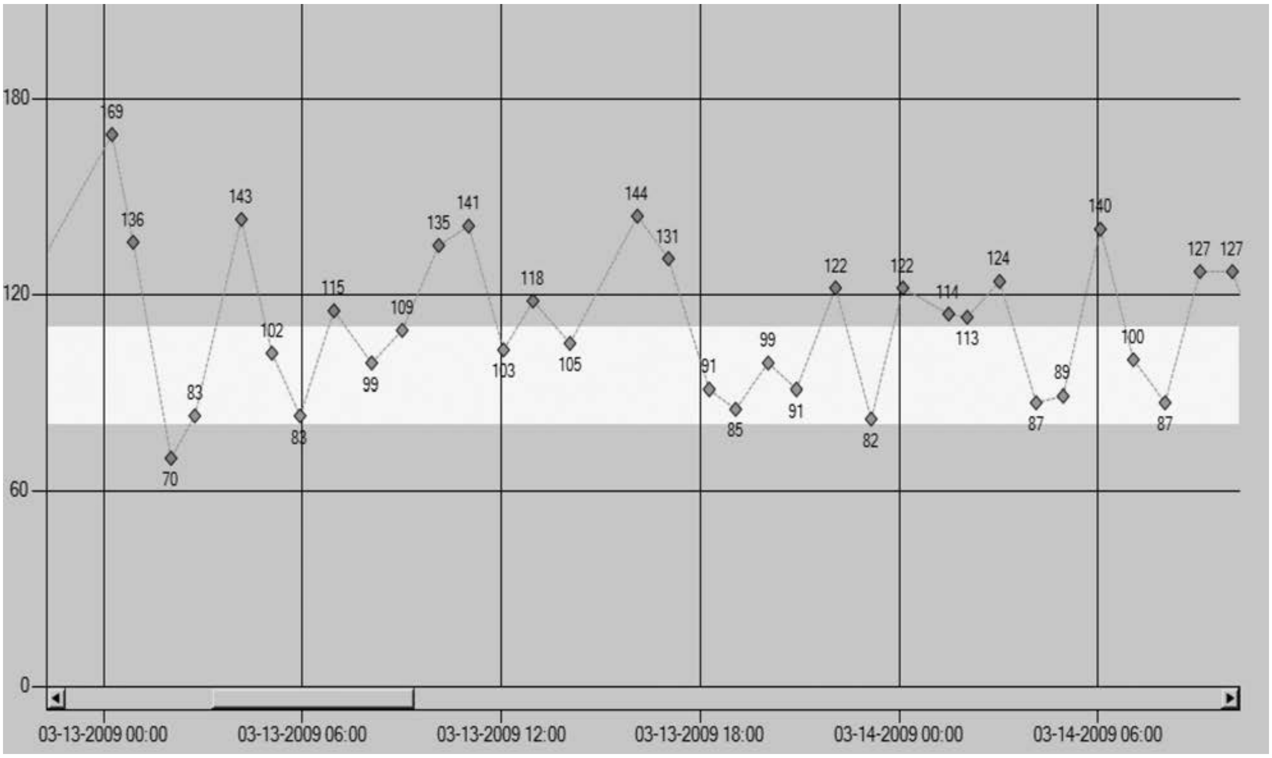

Figure 1. Sample display for the EndoTool glycemic computer decision support system (Hospira Inc). The graph displays each blood glucose measurement over time. The highlighted area represents the target range programmed for the patient (80-110 mg/dL glucose). Moving the cursor over the measurement will display the corresponding insulin infusion amount.

Both DSSs have demonstrated improved outcomes in our burn intensive care unit (ICU). The EndoTool achieves our target glycemic range of 80 to 110 mg/dL of glucose more often than the traditional paper-based insulin titration protocol it replaced, while achieving significantly fewer hypoglycemic episodes.[5] During the initial 48-hour burn fluid resuscitation, we have shown a significant reduction in crystalloid requirements during Burn Resuscitation DSS assisted therapy compared with the previous practice of solely provider-guided resuscitation, while providing adequate fluid replacement.[6]

Because one system is a commercial product (EndoTool), and the other is a software program developed by our own computer engineering team (Burn Resuscitation DSS), we were interested if the clinical users perceived a difference in satisfaction between these 2 systems. The purpose of this study was to determine baseline user satisfaction for the 2 computer DSSs utilized in our burn ICU.

METHODS

This study was approved by the local institutional review board. Recruitment was conducted in a large southwestern level I trauma/ burn center in a 16-bed burn ICU. Currently, 2 DSSs are utilized in our unit: a leased commercial product used to guide insulin titration (EndoTool; Hospira, Inc),[4] which was implemented in January 2009, and DSS software developed in our institution to assist initial burn fluid resuscitation (Burn Resuscitation DSS),[5] which was implemented in November 2007. Training on EndoTool was provided by Hospira Inc, consisting of 40 hours of both didactic and hands-on experiences. In contrast, training for Burn Resuscitation DSS was informal, ranging from in-services to one-on-one instruction with the unit clinical nurse specialist and software developers. The target population for training on both systems was clinical staff who utilized DDS in daily practice to include medical doctors, registered nurses (RNs), and licensed vocational nurses (LVNs).

Data collection was completed by distributing a written questionnaire to all clinical staff (n 82). The participants were encouraged to complete the survey and return them anonymously to envelopes centrally located in the burn unit. Eleven questions utilizing a 5-point Likert scale (where 1 "not at all," 3 "neutral," and 5 "very much") were asked regarding clinical satisfaction of both decision support computer systems.

Descriptive analysis was performed for participant's duration of ICU experience, time working at our burn center, and burn resuscitation experience. A 1-sample Student *t* test was utilized to compare the differences of mean scores to that of neutral (Likert scale 3). In addition, a

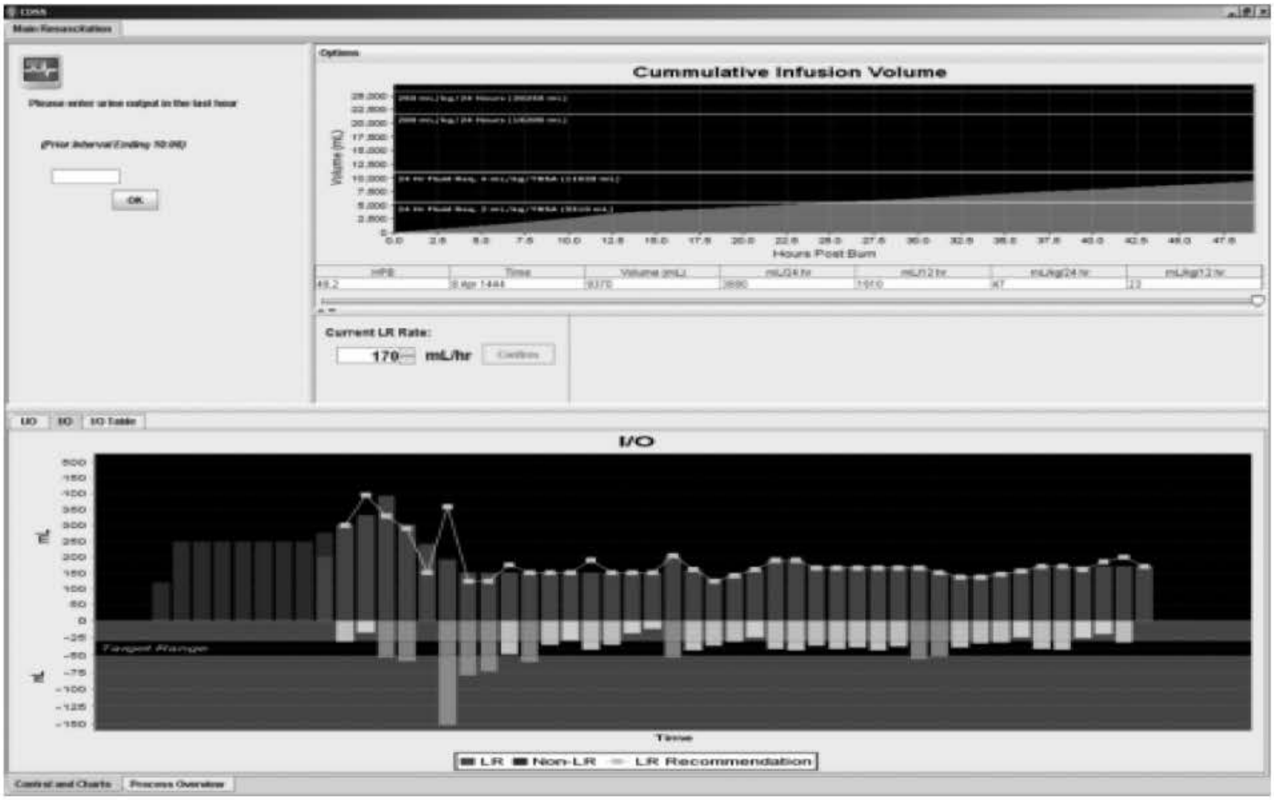

Figure 2. Home screen for the Burn Decision Support System (US Army Institute of Surgical Research). The displays indicate (from top left corner in clockwise order) (1) action area for next scheduled intervention; (2) cumulative infusion volume over the 48-hour resuscitation period, where colors change from green to amber to red to indicate dangerous fluid levels; and (3) hourly fluid recommendation (white dot), actual infusion volume (top bar), and corresponding urinary output (lower bar) color coded to represent in range (green), below range (yellow), and above range (red) Colors are not shown in this depiction.

paired Student *t* test was used to compare Burn Resuscitation DSS scores with EndoTool DSS scores. Significance was accepted for $P < .05$. Data analysis was completed by utilizing PASW statistical software (v. 18; SPSS Inc, Chicago, Illinois).

RESULTS

Forty surveys were returned from our staff (49% response rate, 40/82), consisting of 5 physicians (12.5%), 26 RNs (65.0%), and 9 LVNs (22.5%) (Table 1). Of the 11 questions asked about the EndoTool system, only 4 were found to be significant from neutral (Likert scale 3) by the RN, LVN, and total combined respondents: (1) adequate training, (2) comfort with the system, (3) ease of use, and (4) trust in recommendation ($P < .001$, respectively). A difference for the Burn Resuscitation DSS was noted by the physicians in (1) adequate training, (2) comfort with the system, and (3) a lack of interference with work

TABLE 1 Demographic Profile of Study Participants

	MD	RN	LVN	Total
	n = 5/5 (100%)	n = 26/54 (48%)	n = 9/23 (43%)	n = 40/82 (49%)
Employed in burn center, y	5.6 (5) (1 14)	3.3 (3) (0 13)	3.1 (2.8) (1 8)	3.6 (3.3) (0 14)
ICU experience, y	7.6 (6) (2 18)	8.3 (5.6) (1 19)	5.9 (5.7) (1 15)	7.7 (5.6) (1 19)
Resuscitation with DSS, n	17.5 (5) (10 20)	4 (3.7) (0 12)	7.3 (6) (1 20)	6.2 (6) (0 20)
Resuscitation without DSS, n	80.5 (90) (2 200)	9.6 (20) (0 100)	25.6 (35) (0 100)	20.5 (40) (0 200)

Abbreviations: DSS, decision support system; ICU, intensive care unit; LVN, licensed vocational nurse; MD, medical doctor; RN, registered nurse.
Values are as mean (SD) (range).

($P < .05$, respectively). No difference from neutral was noted for either system for (1) improved care or outcome, (2) increased time in target range, (3) improved understanding of concept, (4) helpfulness for training, or (5) overall satisfaction (Table 2).

When the 2 systems were compared, the only differences noted were that the EndoTool system was perceived to be superior to Burn Resuscitation DSS for combined user responses in (1) adequacy of training, (2) comfort with the system, (3) ease of use, and (4) trust in the recommendation ($P < .001$, respectively) (Table 2).

DISCUSSION

This study of clinician satisfaction with computer DSS used in our burn ICU has revealed a general preference for the commercial glycemic management system (EndoTool) over the unit-developed Burn Resuscitation DSS for initial burn fluid resuscitation. However, when physician and nursing groups are considered independently, the physicians were more satisfied with the training, comfort in use of the system, and decreased interference with work with the Burn Resuscitation DSS than EndoTool. Several reasons may account for this distinction, the first being that implementation of these systems in our ICU differed. The commercial EndoTool system was supported by a professional team of nurse educators who provided a week-long training and "go-live" period. All patients on intravenous insulin infusion were eligible for DSS glycemic management, and several patients were started on the system during the training period. In contrast, the Burn Resuscitation DSS developed within our unit was introduced incrementally over a period of several months as severe burn patients were admitted. Informal one-on-one training was accomplished with the nurses and physicians caring for the individual patient during resuscitation, and unitwide training was not initially conducted.

Large burn injury requiring fluid resuscitation is relatively uncommon (approximately 1 per week), with a maximum duration of only 48 hours. Thus, not all staff members were familiar with or had extensively used the Burn Resuscitation DSS. In addition, during the early stages of development, the software was evolving, likely introducing ambiguity among the staff. Users who lacked expert knowledge of the underlying principles of burn resuscitation may have found this approach confusing. The physicians reported greater satisfaction with Burn Resuscitation DSS training and comfort with the system, perhaps because of the emphasis in soliciting continual feedback regarding system performance during development and the relatively fewer number of staff physicians (n 5) compared with nurses (n 77) in the burn ICU. The nursing staff reported greater satisfaction with EndoTool likely because of the daily use of this system during the routine administration of intravenous insulin, perhaps contributing to the increased satisfaction in ease of use reported for this system. The physicians do not directly interact with either DSS as far as entering hourly inputs into the systems or adjusting infusion rates; thus, the neutral responses for "ease of use" were unremarkable.

A reason for the possible difference in trust in system recommendations is the comfort level of the providers with the underlying processes being managed. As noted, glycemic management is a common practice for all ICU nurses, and insulin titration is generally performed on an hourly basis for extended periods. Understanding the glycemic response of patients to changes made by the nurse can occur quickly, even for the novice. However, fluid resuscitation in severe burn injury is complicated by multiple factors, to include concomitant injury, inhalation injury, organ dysfunction, age, and degree of burn depth.[7] Furthermore, the algorithm guiding the complex process of fluid infusion is based on the single variable of urinary output when in fact multiple physiological processes are part of the overall approach to burn resuscitation. Most nurses have limited experience with the initial 24 hours of burn resuscitation because of the infrequency of admissions compounded by a large nursing staff. This may account for some of the perceived dissatisfaction with the Burn Resuscitation DSS compared with the EndoTool system that may be a result of user bias; medical doctors are more comfortable with directing burn fluid resuscitation, and nurses are at ease with insulin titration.

During our analysis of these results, our team realized that although we have successfully demonstrated that both DSSs have improved patient outcomes (improved glycemic control with fewer episodes of hypoglycemia[5] and decreased fluid requirements for burn resuscitation with improved outcomes,[6] this information had not been formally presented to the staff nurses. Continued feedback of the successes of new technology introduced to the ICU is critical to ensuring staff acceptance and trust in recommendations made by the computer systems. The neutral responses to the question regarding whether the systems resulted in greater time in target range or improvement in patient outcome may reflect this disconnect with the finding of our outcome research. As a result of this realization, we have made a concerted effort to aggressively promote the demonstrated benefits of both DSSs in the care of our burn patients to increase our clinician's satisfaction.

Finally, the neutral response regarding overall user satisfaction with both DSSs provides an opportunity to improve our communication with the clinical staff. We have developed a multifaceted strategy for improving acceptance of new technology in our burn ICU, broadly targeting the areas of interface, information, and communication (Table 3). Our clinical nurse specialists, who have

TABLE 2 Results of Analysis

Burn Resuscitation DSS					EndoTool DSS			
MD	**RN**	**LVN**	**Total**		**MD**	**RN**	**LVN**	**Total**
4.4 (0.9) (3-5)[a]	2 8 (1 2) (1-5)	2 7 (0 7) (1-3)	2 9 (1 2) (1-5)	Q1 Tra n ng adequate?	3 4 (1 7) (1-5)	**4.9 (0.5) (3-5)[b]**	**4.8 (0.4) (4-5)[b]**	**4.7 (0.8) (1-5)[b,c]**
4.2 (0.8) (3-5)[a]	3 2 (1 1) (1-5)	2 7 (0 9) (1-4)	3 2 (1 1) (1-5)	Q2 Comfortab e w th the system?	3 2 (1 8) (1-5)	**4.7 (0.6) (3-5)[b]**	**4.3 (1.0) (2-5)[b]**	**4.4 (1.0) (1-5)[b,c]**
3 6 (1 1) (2-5)	3 3 (0 8) (2-5)	3 2 (1 2) (1-5)	3 3 (0 9) (1-5)	Q3 System easy to use?	3 4 (1 7) (1-5)	**4.6 (0.6) (3-5)[b]**	**4.2 (1.3) (2-5)[b]**	**4.4 (1.0) (1-5)[b,c]**
3 0 (1 4) (1-4)	3 0 (0 8) (1-4)	2 7 (1 0) (1-4)	2 95 (0 9) (1-4)	Q4 Trust recommendat on?	3 4 (0 9) (3-5)	**4.5 (0.7) (3-5)[b]**	**4.4 (0.7) (3-5)[b]**	**4.4 (0.8) (3-5)[b,c]**
1.8 (0.8) (1-3)[a]	2 9 (1 1) (1-5)	2 6 (1 0) (1-4)	2 7 (1 1) (1-5)	Q5 nterference w th work?	3 0 (1 6) (1-5)	2 9 (1 0) (1-5)	2 7 (0 9) (1-4)	2 9 (1 0) (1-5)
3 6 (1 3) (2-5)	3 3 (0 9) (1-5)	2 8 (1 0) (1-4)	3 2 (1 0) (1-5)	Q6 Does system mprove care?	2 2 (1 8) (1-5)	3 2 (1 1) (1-5)	2 7 (1 4) (1-5)	2 95 (1 3) (1-5)
3 8 (1 3) (2-5)	3 1 (0 8) (1-4)	2 9 (1 0) (1-5)	3 2 (1 0) (1-5)	Q7 s t me n target range ncreased?	3 4 (1 1) (2-5)	3 2 (1 0) (1-5)	3 2 (0 7) (2-4)	3 2 (1 0) (1-5)
3 8 (1 3) (2-5)	3 2 (0 8) (1-5)	2 9 (1 2) (1-5)	3 2 (1 0) (1-5)	Q8 s overa outcome mproved?	4 0 (1 0) (3-5)	3 1 (1 0) (1-5)	3 2 (0 8) (2-4)	3 3 (1 0) (1-5)
2 8 (1 5) (1-5)	2 9 (0 8) (1-4)	2 9 (1 1) (1-4)	2 9 (1 0) (1-5)	Q9 s your understand ng mproved?	3 0 (1 2) (2-5)	2 7 (1 0) (1-5)	2 8 (0 7) (2-4)	2 8 (1 1) (1-5)
3 4 (1 1) (2-5)	3 0 (1 1) (1-5)	2 7 (1 0) (1-4)	3 0 (1 1) (1-5)	Q10 s the system he pfu for tra n ng?	3 0 (1 2) (2-5)	2 8 (1 2) (1-5)	2 8 (0 8) (2-4)	2 8 (1 1) (1-5)
3 8 (1 0) (3-5)	3 1 (0 8) (1-4)	3 3 (0 8) (2-5)	3 3 (0 8) (1-5)	Q11 Overa sat sfact on w th system?	4 3 (1 0) (3-5)	3 1 (1 0) (1-5)	3 1 (1 0) (1-4)	3 2 (1 0) (1-5)

Abbrev at ons DSS, dec s on support system; CU, ntens ve care un t; LVN, censed vocat ona nurse; MD, med ca doctor; RN, reg stered nurse
Va ues are reported as mean (SD) (range)
Data n bo d font nd cate $P < 0 05$
[a]$P <$ 05, 1-samp e Student t test compar ng score w th neutra = 3
[b]$P <$ 001, 1-samp e Student t test compar ng score w th neutra = 3
[c]$P <$ 001, pa red t test compar ng burn resusc tat on DSS and EndoToo scores

TABLE 3 Strategies to Improve User Acceptance of Computer Decision Support Systems (DSSs)

1. Interface
   - Elicit user feedback on a routine basis development, deployment, and ongoing operations
   - Programmers would appreciate at least 2 hours per week from routine user to assist in product development
   - Rewards for user audible tones, levels of achievement, points toward a goal similar to video games
   - Keep some kind of patient information readily available to avoid mistakes in patient selection
   - Develop a "training module" for new users and ongoing education; demonstrate system processes to allow practice for user interface
2. Information
   - Keep it simple: give a brief overview/outline of the underlying algorithm

     Example for glycemic control
     - 1. Enter blood glucose
     - 2. System projects next hour insulin infusion rate
     - 3. System makes recommendation based on user input
     - 4. Wait recommended time for next input
   - Provide explanations for DSS recommendations "why"
   - Ensure user has grasp of underlying process DSS is guiding (example: principles of glycemic control or burn resuscitation)
3. Communication
   - Inform user where the system "is" or where the system "is going"
   - Provide mechanism for ongoing user feedback to programmers/ development team DSS is an iterative development process, a "living" application
   - Provide users with effect of DSS on patient outcomes improve user buy in to the initial inconvenience to workflow with improvement in care

traditionally been the leaders in introducing and modifying the computer systems, are the primary initiators of coordination among the providers and the software developers. In fact, we have noted improvement in bidirectional communication among the nursing staff and physicians, stimulating discussions regarding best practices and ways to standardize patient care. The Burn Resuscitation DSS record serves as a useful means to review difficult resuscitations during interdisciplinary rounds and provides teaching opportunities for new staff members. Future satisfaction surveys are planned to ensure our interventions are effective in providing feedback to the software developers to inform and improve the systems. Such surveys will provide guidance for future research and implications of incorporation of computer technology in clinical care of ICU patients.

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